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IX.

CAUSES OF MILD TEMPERATURE, &C., OF OUR INTERIOR AND WESTERLY NORTHERN LATITUDES.

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Communicated.

No single cause, perhaps, can be designated that will account for the meteorological phenomena already known in connection with the extreme northern latitudes of the United States. The fact is well established, that there are zones of country between latitudes 45° and 49° north in which the climate is materially milder, and the snow-fall much less, than in more southern latitudes. This, of course, is contrary to the general impression, that the farther north, the greater the cold and the deeper the snow. It is equally clear that there are sufficient reasons for the apparent anomaly. Does our present knowledge enable us to define these? Of one fact we may feel assured, that there has been no perceptible or essential change in the climatic characteristics of the region under consideration since the days of Lewis and Clarke, the great original explorers of the general route now soon to be traversed by the modern railroad. They were not looking for, or thinking of, railroad routes, for their admirable continental exploration was effected more than twenty years prior to the railroad advent, in the very beginning of the present century. Their graphic accounts still remain accurately descriptive of the extensive range of country traversed between the waters of the Missouri and the Pacific Ocean, and show that the very same peculiar climatic characteristics now observed, existed in 1804–5, nearly seventy years ago.

Since the time of Lewis and Clarke, meteorology has become more cf a science, and numerous observations on land and sea have been collated, and now form the basis of our present knowledge of the air and water currents of this region. Besides, the love of gold, and the calculated fanaticism of Joe. Smith's Mormon leaders, carried thousands of people into the interior of the Rocky-Mountain regions which otherwise might have continued to be *terra incognita* for a long period in the future; so that for some years the Pacific slope, from San Francisco to the northern boundary, latitude 49°, separating the United States from British Columbia, has had an influx of intelligent population from the Eastern States, some of them observers.

The isothermal lines, or lines of equal temperature, instead of passing directly west along the parallels of latitude, incline northward, far up into the valleys of British Columbia. These isothermal lines are more real than the lines of latitude. What are the causes of the northerly trend of these curves of equal temperature? We ascribe them to several primary causes: First, the flow of the comparatively warm currents of the Pacific Ocean eastward striking upon the coast, passing both north-eastward and southward, warming the air, and ameliorating the climate of the lands bordering on the Pacific; second, the flow of the comparatively warm air from the Pacific Ocean, passing landward, and raising the temperature that might otherwise be due to latitudes 45° to 49° north; third, the existence of the two great nearly parallel ranges of mountains,—the Cascade range, within about one hundred miles of the Pacific Ocean, and the main range of the Rocky Mountains, and its vast spurs, about eight hundred miles east of the same coast; fourth, the fact that the passes or depressions of the Rocky Mountains to the northward become lower, by more than two thousand feet, thus allowing the warm upper winds from the Pacific, or portions thereof, after flowing over the comparatively dry and treeless plains of the great Columbia valley, to pass through to the valleys along the headwaters of the Missouri, thus ameliorating to some extent their climates. There may be other causes, arising from the general topography of the interior; but this article is not intended to be exhaustive; is not designed to cover all the various auxiliary causes, which hereafter may be better known than they are now.

What are the general consequences of the operation of the causes we have just described? Among them are — first, a peculiar and remarkable climate west of the Cascade range of mountains, somewhat resembling a tropical climate, giving about five months of comparatively mild, rainy weather, and about seven months of warm weather, comparatively devoid of rain, with very little snow in winter in the valleys, and only light freezing weather after the middle of January. The winters are usually so short and so mild, that sometimes they cannot get ice for their ice-houses; and flowers which would be killed on the Atlantic coast in the latitude of

Philadelphia or Baltimore remain out all winter uninjured along the Lower Columbia and around Puget Sound, between latitudes 46° and 48° north. Were it not for the tempering heat from the warm waters, and the warm air of the Pacific Ocean, such phenomena could not occur. Second, the Coast or Olympic range, west of Puget Sound, and the Cascade range, eastward of the Sound, already mentioned, lie almost parallel with the coast-line, and lift their ragged summits to the height of 5,000 to 8,000 feet, the loftier peaks being still more elevated; Mount Rainier, in Washington Territory, having a height of 12,330 feet. The general range of elevation may be about 7,000 feet; the passes being only from 3,000 to 4,000 feet high. These ranges are the condensers, — the first set of condensers landward from the coast. They condense the moist, warm atmosphere from the ocean, and in winter they accumulate immense masses of snow; while the summits of the higher peaks, and for several thousands of feet down, are perpetually snow-clad. The Columbia River cuts through the Cascade Mountains, and a portion (comparatively limited, of course) of the lowest stratum of the warm, moist air from the Pacific passes inward; but the bulk of the moisture in the lower atmosphere, perhaps to the height of 5,000 or 6,000 feet above the sea, is precipitated on the cool slopes of this mountain-range, and returned during the spring and summer to the ocean by the rivers flowing into the Columbia, etc., and into Puget Sound. The warm, though less moist, stratum of air from the ocean, ranging above the general level of the Cascade Mountains, passes on, high above the treeless Columbia plains, till it impinges against the immense westerly spurs of the Rocky Mountains, when another precipitation takes place. The Bitter-Root Mountains, the most westerly prong in this latitude (45° to 47°), are not quite so high as the main range, although they are from 6,000 to 8,000 feet or more above the sea, but with some passes as low as 5,000 feet.

Clarke's Fork of the Columbia cuts through this great Bitter-Root range; and here, in the valley of Clarke's Fork, and around the Cœur d'Alĕne and Pend d'Oreille lakes (Lake Pend d'Oreille, like the Tappan Zee on the Hudson, is in fact an enlargement of Clarke's Fork of Columbia River, which flows through it), as well as on the slopes of the mountains, we again find a splendid growth of timber, after an interval of several hundred miles of almost treeless, grassy plains; these plains rarely receiving much snow, and having, generally, an insufficient quantity of rain.

Following up Clarke's Fork to its various head-waters on the Bitter-Root range, and still farther eastward to its extreme easterly sources in the main range of the Rocky Mountains, the whole plane of the country gradually rises; so that at the actual mountain-base the valleys are from 3,500 to 4,000 feet above the level of the sea.

The Bitter-Root range precipitates very much less snow than the Cascade range, but more than is precipitated farther eastward on the main range; while the quantity of snow in the adjacent valleys is usually quite moderate; so that, following eastwardly along the valleys of the Columbia River and its tributaries to their sources, the depth of snow in the valleys is nowhere very great; while on the mountains, on both sides of the valleys, it may be several feet deep. Some of the passes of the main range are less than 6,000 feet above the sea, and the depth of snow on the summits of these very rarely exceeds eighteen inches; while on the passes of the Cascade range, which are from two to three thousand feet lower, but so much nearer to the coast, there is a depth of many feet every winter.

Immediately east of the main range of the Rocky Mountains, in these same latitudes (45° to 47° north), — take, for instance, the vicinity of Helena (about latitude 46½°), the commercial capital of Montana, which is at the base of the mountains about 4,200 feet above the sea, somewhat elevated above the Missouri River (only fifteen miles distant), — the quantity of rain and snow is quite moderate; and the air, stripped of its moisture by the mountains, is generally dry. Snow sometimes will fall here in the valleys to the depth of a few inches, and then, without leaving much, or perhaps any, visible moisture on the ground, evaporate, and disappear in a few hours. Although it is well known, that, as a rule, cold air descends and warm air rises, yet occasionally, when partial vacuums are formed by the sudden condensation of air by cold, the warm air, even from above, rushes in to fill them. In Montana, they call these warm rushing airs "chinook winds".

Without undertaking to offer at present a scientific rationale of the origin, formation, or precise movement of these peculiar winds, further than above, we may state that their effect is certainly very important; for, after the middle of January, the early spring climate of this part of Montana, in latitude 46½° north, at an elevation of over 4,000 feet above the sea, on the eastern foot-hills of the Rocky Mountains, is milder than in the city of New York; and regular ploughing begins in February. From this portion of Montana, the general plane of the country descends continuously very gradually eastward, along the main valley of the Missouri; and also eastward from the westerly elbow of the Yellowstone to its junction with the Missouri. In all of these valleys, the amount of snowfall and rainfall is never great; the winters, excepting for very brief periods, usually in December, are not very severe; and cattle brouse there and live through ordinary winters without artificial shelter or artificial feeding; although at times, in some years, there come severe cold spells of a few weeks, and peculiar conditions of the air and snow, which render feeding and shelter necessary. The country along the Cascade range, and between the Cascade range and the Pacific Ocean, is probably the greatest timber region on the globe. The unusual moisture, doubtless, is one of the causes; and the soil is very good. Fine timber continues up the slopes of the mountains on both sides, almost to their very summits, on these coast-ranges; while the higher peaks are treeless, and always snow-covered above an elevation of about 8,000 feet. The Bitter-Root range also abounds with fine timber; but it is not equal in quantity, save in certain localities, to the timber along and westward of the Cascade range. The timber on the main range of the Rocky Mountains is not equal in quality or quantity to that on the Bitter-Root range, although in places it is good; while the intervening valleys and slopes everywhere are grass-covered and almost treeless. Indeed, the grass extends generally to the tops of the Rocky Mountains in these latitudes. At the Deer Lodge Pass of the main range, between five and six thousand feet above the sea, the grazing is excellent, and the snow is rarely more than a foot deep. Throughout this region, whether on the hills or in the valleys, cattle thrive even in winter upon the abundant bunch-grass, as it is called.

Passing eastward from the main range, descending either by the Missouri, or by its great confluent the Yellowstone, the pine-forests, at first plentiful, though not dense, on the adjacent mountains and ridges, gradually thin out; so that down the Missouri, and towards the mouth of the Yellowstone, and below, along the Missouri valley, in the vicinity of Fort McKeen, near Heart River, the country becomes comparatively treeless, having only cottonwood, etc., along the margins of the streams. Throughout all this vast region, for 600 miles or more eastward of the Rocky Mountains, as far eastward as the one hundredth degree of longitude, at the Missouri River, about the latitude 46¾° north, the winter climate is milder than it is on the same parallel farther eastward in Dakota or Minnesota.

The passes of the Rocky Mountains in British Columbia decrease in height northward above the boundary of 49°, and the country becomes broken into a succession of parallel ridges having a trend about N. N. W., among which are the sources of the Upper Columbia on the west, and the Saskatchawan on the east. The Upper Columbia River in British Columbia presents a very remarkable course, somewhat resembling, though on a larger scale, the Upper Alleghany River of Western Pennsylvania and New York. It rises nearly as far south as 50°, runs N. N. W. at the foot of and parallel with the western slopes of the Rocky Mountains, for over 150 miles, to about latitude 52° 10′ north; then turns abruptly and runs about 250 miles nearly due south, at the foot of and parallel with the Snow Mountains of British Columbia down to the boundary line of the United States (latitude 49°), and thence on a very sinuous course southerly and westerly through Washington Territory. This peculiar topographical feature of the river shows that the plane of the country at the western base of the Rocky Mountains descends northward, while it is exactly reversed at the eastern base of the Snow Mountains, and descends to the south.

The Snow Mountains constitute a very marked feature in the general topography of this part of British Columbia adjoining the United States. This range begins at or near the boundary, latitude 49°, and continues a little west of north for more than 200 miles. The waters of the Columbia, on its eastern base, as already remarked, and the waters of the Okinagaw on the western base, an important confluent of the Columbia, flow southward to their junction about latitude 48°, longitude 120°, in Washington Territory. The Snow Mountains, from their position and extent, must materially affect the moisture and the temperature of the winds reaching them from the Pacific coast, after these winds have passed the two nearly parallel coast-ranges, which in British Columbia are even more marked and better defined mountains than their prolongation in the United States already referred to: but we have not sufficient meteorological data to speak definitely of the climatic effect of the Snow Mountains. We may, however, infer that the upper stratum of air from the Pacific, after clearing the coast-range, would, in winter, in passing eastward, gradually cool, descend obliquely, and part with its moisture on the mountains in the shape of snow; and that the still higher strata, too elevated to impinge against the Snow Mountains, would continue on, still descending obliquely, till they should strike the main Rocky-Mountain range, about one hundred miles farther east.

A curious circumstance in the Rocky-Mountain topography of this part of British Columbia (latitude 51° to 53°) is, that, while the passes are lower than those farther south in the United States, the great peaks are reputed to be higher,—higher even than the highest of the Rocky-Mountain peaks in the United States. Thus Mount Hooke and Mount Brown, near the great northerly bend of the Columbia, are called respectively 15,700 and 16,000 feet high. There are great valleys eastward of the Rocky-Mountain range in the Saskatchawan country, such as the Saskatchawan valley, which are not only habitable, but highly advantageous as agricultural regions, especially for grazing and the raising of wheat and other cereals. One great topographical feature of that part of our continent in the United States, ranging between latitude 45° and 48°, and between longitude 92° and 122°, from Lake Superior to Puget Sound (an air-line distance of about 400 miles), is this,—that no mountains intervene between the great plains of little elevation west of Lake Superior and the spurs of the Rocky Mountains. All the way from the lake to the Missouri River, 450 miles, is a succession of gently undulating surfaces. The Missouri valley itself is, of course, a gradually descending plane, beginning in the Rocky Mountains, and ending, through the Mississippi, in the Gulf of Mexico.

The Upper Missouri cuts through to their bases all of the spurs of the Rocky Mountains on the eastern side; while Clarke's Fork of the Columbia cuts through to their bases all of the spurs on the western side; thus presenting gradual river-valley slopes from the main dividing passes of the Rocky Mountains to the Atlantic, (Gulf of Mexico) on the one side, and to the Pacific Ocean on the other. Nowhere else on the continent can similar great valleys, such as the Missouri and the Columbia, be found meeting advantageously at a common point on the main dividing backbone which separates the continental waters flowing east and west to the two oceans. The heads of these main valleys, among the foot-hills of the Rocky-Mountain range, as remarked, are here only from three to four thonsand feet above the sea, while the great treeless plains, only four to five hundred miles south (about latitude 40° to 42°), between the Black Hills, immediately west of Cheyenne, and the rim of Salt Lake basin, are elevated more than 6,000 feet above the sea for a distance of over 300 miles east and west. Here the topography is entirely different from the regions to the north. The most remarkable topographical feature of the country along latitude 40° to 42° are the extensive rolling plains, which include the Great Salt Lake basin and the Humboldt River, having a general elevation ranging from 4,000 to 6,000 feet above the sea, with still more elevated land entirely surrounding them. The Bear River, Weber River, and other considerable streams, rising in spurs of the Rocky Mountains, flow into the Great Salt Lake; but the amount of snowfall and rainfall upon their tributary watershed is only equivalent to the evaporation from the same area; so that the lake maintains, within a few feet of irregular fluctuation, the same general level, and the same saltness, without having any flow outward. The Humboldt River basin, although on a higher level, is of the same general character, the river ending in lakes having no outlet, while all the snowfall and rainfall is taken up by evaporation. The Green River, a principal tributary of the Colorado, which rises about latitude 43° and longitude 110°, flows southward, cutting across the plains west of the Black Hills, and joins the Grand River about latitude 38°, the two forming the Colorado, which flows southward to the Gulf of California, about latitude 32° and longitude 114°. This is the only stream from the plains that flows to the ocean; but in the fall the Green River contains a comparatively small body of water. Probably the mean annual temperature of the Pacific Ocean, opposite latitude 32°, is but little, if any, warmer than it is off the Bay of San Francisco, owing to the curved flow of the equatorial current impinging against the coast, even farther north than the Strait of Juan de Fuca opposite Puget Sound, thence turning southward along the coast, passing the Bay of San Francisco and merging into the mild temperature of the ocean farther south. The amount of rainfall on the plains between the coast range and the ocean, from latitude 40° southward as far as latitude 32°, near the southern boundary of the United States, is very much less than it is northward of latitude 40°, as far as latitude 46°, near the mouth of the Columbia, and even to 48° north, near the entrance to Puget Sound. There is no snowfall south of latitude 40° along the coast (excepting on the mountain range) while on the high foot-hill plains northward, intervening between the Bay of San Francisco and the Columbia valley, considerable snow falls. The coast-range and its spurs are the condensers; while the warm aqueous atmosphere of the ocean adjacent to and west of them is conveyed eastward, and, when condensed, produces the snow and rain on the foot-hills and mountains. The water thus condensed affords sustenance to large bodies of timber and strong vegetable growths; while eastward thereof the elevated plains, which are about 6,000 feet above the sea, are treeless and dry, owing, in part, to the want of moisture. Experience has shown that the soil of these high plains, about latitude 38° to 40°, in many places is quite fertile, needing only water for irrigation to render it productive. The summers are, however, very short, the winters very long; and this entire elevated region is too frosty for extensive, general agriculture. Six degrees farther north, in the range of latitude 46° to 47°, along the valleys of the Columbia, the climate is more equable, and, being much more moist, agriculture flourishes.

The Willamette valley, west of the Cascade range (of which Portland, Oregon, is the commercial centre), is one of the side-valleys of the Columbia River basin, comprising an area of 4,000,000 acres, upon which the rainfall is abundant, owing to its proximity to the Pacific Ocean and its position among the mountains.

Another of the meteorological facts of the Pacific coast is, that, while the greatest rainfall in the United States occurs in the vicinity of the Columbia River and the southern portions of Puget Sound, in latitude 46° to 47° north, where the yearly rainfall is 76 inches, the least rainfall occurs on the same coast near our southern boundary, latitude 32°, where the average annual rainfall is only three inches.

The maximum difference of temperature of the lowest stratum of the atmosphere between the ocean-air and the land-air in winter seems to occur at or near the outlet of the Columbia valley; but that may be considered to be in part local, at least during the winter and spring, when the cold, fresh waters in immense volumes, flowing from the melting snow of the interior mountains, meet the warmer waters of the Pacific, causing unusual condensation and dense fogs. We may not yet have sufficient meteorological data on the Pacific coast, and in connection therewith for 800 to 1,000 miles eastward, reaching to the main range of the Rocky Mountains, or the data at command may not yet be sufficiently elaborated, to enable us to generalize definitively respecting the exact movements and effects of the oceanic and land air-currents over this part of our continent. The facts herein glanced at are offered, not as settling any question, but as adjuncts in the further elucidation of this most interesting subject.

It seems probable that by the time the upper volumes of the atmosphere flowing eastward from the Pacific reach the interior of the continent, especially after having passed the Rocky-Mountain range, they have become divested of a large portion of their moisture and latent and sensible heat. Such cold upper strata are then ready to descend eastward obliquely, until they may meet with other strata of the same temperature; but by the time this can occur, supposing that to be at or not far from longitude 100°, other important elements enter into the question both of temperature and humidity.

The great basin of the Missouri River, lying nearly north-west and south-east, is here encountered. The north and north-west winds engendered by difference of temperature, due in part to difference of latitude, during the fall and early part of winter, flow southward or south-eastward along this great valley, meeting obliquely, and falling in with the elevated westerly winds from over the Rocky Mountains. Or these same westerly winds from the higher atmosphere, which have passed above the Rocky Mountains and become cold, may meet moister and warmer winds passing westward from the great lake region, and immediately cause condensation and snow over the extensive prairies east of the Missouri River. On these prairies, the winds in winter do not generally continue long in one direction. Sometimes they blow strongly from the south, and, when occasionally continued for some days, bring mild weather.

The great atmospheric movements here referred to may to some extent account for the sudden and severe cold sometimes experienced on these plains; although the complete rationale of all this may not yet be understood. The extensive Winnipeg Lake system, lying only about 400 miles north of the region just under consideration, may also materially affect this question. When the air is comparatively warm, and therefore rising from the plains, of necessity colder air rushes in to take its place; but the mere fact of the presence of cold at the meteorological stations on or near the Rocky Mountains, where observations have been made, does not prove that its effect will be sensibly felt near the earth six or eight hundred miles eastward, although at times it will be. The barometrical and thermometrical records collected on these extended areas, when intelligently collated at the Signal Office in connection with the known force and direction of the movements of the lower atmosphere at the different points, afford, however, the means of ascertaining the probable force as well as the course of severe storms some time in advance of their arrival at other given places. The primal causes which induce every movement of the atmosphere must be unvarying; but their combinations, acting sometimes in unison and at other times in opposition, in whole or in part, lead to all the irregularities in the phenomena which are found over so large a portion of the globe. Probably the range of latitude from 36° to 48°, on the American continent, is subject to greater and more sudden variations of temperature than any other portion of the earth; and this may be traced, we think, chiefly, to its peculiar topography of mountains and plains, lakes and rivers, with reference to the Atlantic Ocean on the east and the Pacific on the west, with a vast territory extending northward to within fifteen degrees of the pole, embracing immense land-areas which are too far from the Atlantic and Pacific oceans to be materially affected, directly, by their ocean-atmospheres. The surface-winds from these northerly regions are always colder than the surface-winds from the south.

Concerning the temperature, or even the movements, of the higher strata of the air, our knowledge, practically, is yet very limited; although by reasoning we obtain some insight into their probable meteorological phenomena based on the permanent primal causes referred to. Future observations, when they can be made, of the movements and effect of the higher strata of the atmosphere in connection with those of the lower strata (which are now daily becoming better understood), it is hoped, may reveal to us valuable scientific data which shall serve to systematize into practical shape the meteorology of the whole continent.

The movements of clouds afford some knowledge of the direction, and in a degree of the velocity, of the different middle strata of the atmosphere, so far as they can now be observed; but above such cloud movements. and in clear weather, our observations of higher strata can only be made from elevated mountain-places, or by means of kite-balloons sent up for the purpose. Since the movements of these elevated bodies of air must in the nature of things affect the lower meteorology with which we are now becoming familiar, it may be well for our scientific observers to urge the employment of the requisite means for obtaining such practical knowledge of them as may be obtainable through the means above indicated or in any way deemed most practicable.

This suggestion is applicable to the Atlantic States as well as to the interior. At present, nearly all our observations of the thermometer, barometer, the direction of the wind, etc., are confined to points near to or at most within a few hundred feet of the earth's surface; while we know, from occasional experience, that at no great elevation the wind may be blowing a contrary course to that observed near the surface.

Clouds are sometimes seen at different elevations moving in three different directions. A knowledge of these upper motions may enable us to obtain more reliable generalizations respecting the probable movements of storms. It is a curious meteorological fact that, while the snow-line on the Pacific coast, in latitude 46°, is only about 8,000 feet above the sea, it is about 12,000 feet at the Rocky Mountains, 800 miles inland from the ocean.